BENCHTOP INSTRUMENTS

Test Battery Chargers with Load Simulator

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Several years ago, I designed a charging circuit for a pack of rechargeable batteries that powered a handheld printer. I tested the charging circuit by charging one battery pack after another. If you're still testing your battery-charger designs this way, you can use a circuit designed by Linear Technology (**Fig. 1**) as a substitute for all those batteries.[1]

If your charger monitors battery voltage and adjusts the output current, then you can use this circuit to test the charger's output current as a function of battery voltage. With this circuit, you can perform long-term testing of a battery charger without ever overcharging a battery. And, this circuit can simulate any kind of rechargeable battery.

The circuit looks like a voltage regulator, and that's what it is. With this "battery simulator," you can test a battery charger under a constant-voltage load. The circuit lets you adjust the load voltage through a potentiometer.

To set that voltage, adjust the potentiometer from 0 V to 2.5 V (S1 closed) or from 2.5 V to 5 V (S1 open) as measured at the op amp's noninverting input. The op amp amplifies its input voltage by 4 ([10 k + 30 k] / 10 k), which causes it to supply an output voltage of 3.5–10 V or 10–20 V. Although you can set the op amp's noninverting input to 0 V, the actual voltage of the circuit (V_{in}) won't go below approximately 3.5 V because of voltage drops across Q1. You can get lower voltages by replacing the top LT1004-2.5 Zener diode with a 1.2-V device and changing R1 from 10 k to 1 k.

The op amp drives Q1, a high-gain Darlington transistor, which sinks most of the charger's current. Q1 can dissipate considerable power, so you'll need to use an adequate heat sink. For example, V_{CE} = 5 V and I_C = 3 A, so Q1 will dissipate 15 W.

Be sure to include the 510-Ω and 1.1-k resistors at Q1. The 510-Ω resistor increases Q1's stability, eliminating any chance of oscillations, and

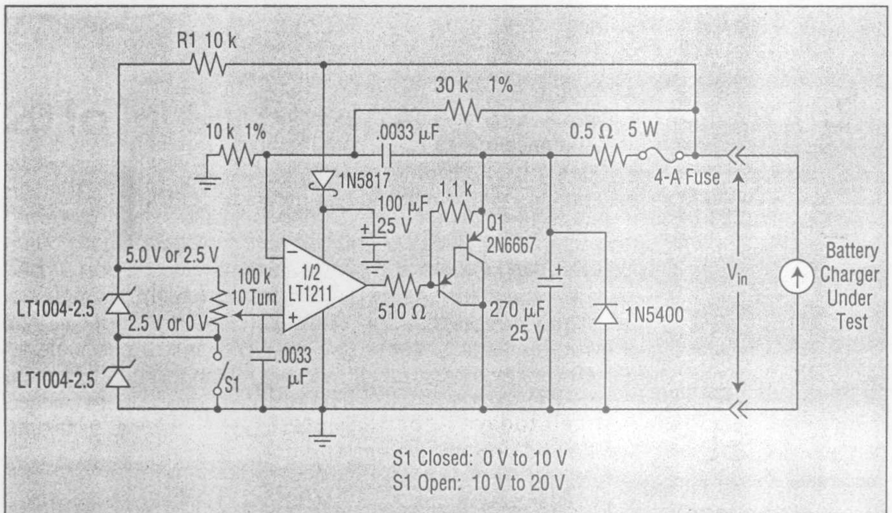

FIGURE 1. Use this circuit to simulate a rechargeable battery for testing battery chargers. (*Courtesy of* Linear Technology Magazine.)

the 1.1-k resistor helps Q1 turn off. The 4-A fuse and the 1N5400 diode protect the simulator circuit from reverse voltages. Use the 270-µF capacitor to filter any high frequencies that might be on the simulator's input.

Some of the charger's current provides power for the op amp through the 1N5817 diode. If you add the 100-µF capacitor to the op amp's power-supply pin, you'll provide enough current to keep the op amp powered for 50 ms per 100 µF.

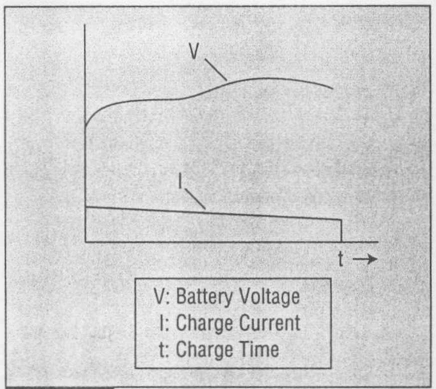

FIGURE 2. A NiCd battery's voltage increases nonlinearly as a charger supplies charge current.

Constant Voltage

The circuit holds its output voltage nearly constant for charge currents from about 50 mA to 3 A, although you should be able to operate the circuit down to 30 mA. Assume you need to simulate a pack of four 1.2-V NiCd batteries. Connect the simulator circuit to your charging circuit (see Figure 1), and connect a voltmeter across the simulator's terminals. Adjust V_{in} with the potentiometer, and measure the voltage with a voltmeter. Then, connect the voltmeter across the simulator's 0.5-Ω resistor. You can calculate current by measuring the voltage across the 0.5-Ω resistor and multiplying the voltage by 2.

When testing your product's charging circuit, you can simulate a battery pack by adjusting the circuit's output voltage to follow the curve in **Figure 2**, which shows the charging voltage of a NiCd battery. To simulate a pack of four batteries, adjust the voltage to peak at around 5.0 V to 5.1 V, then back off until the voltage is closer to the nominal 4.8 V. For long-term testing, you can replace the LT1004-2.5 Zener diodes and the potentiometer with a digital-to-analog converter and control the circuit's output voltage from a PC. Then, you can program the PC to simulate the voltage curve in Figure 2 and test the charger overnight. *T&MW*

FOOTNOTE

1. This circuit originally appeared in *Linear Technology Magazine,* August 1996, p. 26. Linear Technology, Milpitas, CA. Web: *www.linear-tech.com.* Used with permission.

FOR FURTHER READING

Linden, David, *Handbook of Batteries,* 2nd. ed., McGraw Hill, New York, NY. ISBN: 0-07-037921-1. 1995.